BAIKAL experiment: status report

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We review the present status of the Baikal Neutrino Project and present the results obtained with the deep underwater neutrino telescope *NT-200*

1. INTRODUCTION

The Baikal Neutrino Telescope is deployed in Lake Baikal, Siberia, 3.6 km from shore at a depth of 1.1 km. The present stage of the telescope, *NT-200* [1], was put into operation at April, 1998. Results of searches for atmospheric neutrinos, WIMPs and magnetic monopoles obtained with *NT-200* have been presented elsewhere [2]. During three winter seasons, starting with 1998, a Cherenkov EAS array, consisting of four *QUASAR–370* phototubes was deployed on the ice, just above the underwater telescope, with the aim to study the angular resolution of the latter. Analysis of data show that the angular resolution of underwater telescope for vertical muons after modest cuts is about 4^0.

In the last winter expedition we continued to study the feasibility of acoustic detection of EAS cores in water with an EAS array and four hydrophones. During the EAS array life time of 154 hours, almost 2400 showers with energies above 5 PeV have been recorded. Coincidence data of the EAS array and hydrophones are presently analyzed. Also investigations of water parameters have been continued. Independent measurements of light absorption and scattering have been performed by BAIKAL and NEMO (A.Capone et al.) groups. Preliminary results indicate that the two independent sets of optical data are in a good agreement.

In the course of the last expedition we also lowered a special string with instruments for diverse

goals, in particular to measure the group velocity of light in water at two different wavelengths and to test a two-channel optical module and a calibration light beacon.

Below, we present new results of a search for a diffuse high energy neutrino flux with the neutrino telescope *NT-200*.

2. A SEARCH FOR HIGH ENERGY NEUTRINOS

The used search strategy for high energy neutrinos relies on the detection of the Cherenkov light emitted by the electro-magnetic and (or) hadronic particle cascades and high energy muons produced at the neutrino interaction vertex in a large volume around the neutrino telescope. A cut is applied which accepts only time patterns corresponding to upward traveling light signals.

Within the 234 days of the detector livetime, $1.67\cdot10^8$ events with $N_{hit} \geq 4$ have been selected. For this analysis we used events with $N_{hit} > 10$.

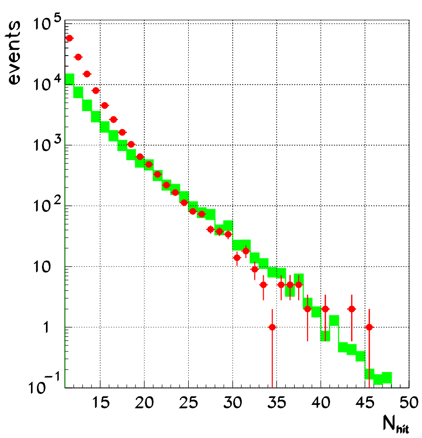

Figure 1. Distribution of hit channel multiplicity; dots - experiment, hatched boxes - expectation from brems and hadronic showers produced by atmospheric muons.

Fig.1 shows the N_{hit} distribution for experiment (dots) as well as the one expected for the background from brems- and hadronic showers produced by atmospheric muons (boxes). The experimental distribution is consistent with the background expectation for $N_{hit} > 18$. For lower N_{hit} values the contribution of atmospheric muons close to horizon as well as low energy showers from e^+e^- pair production become important. No statistically significant excess over background expectation from atmospheric muon induced showers has been observed. Since no events with $N_{hit} > 45$ are found in our data we can derive upper limits on the flux of high energy neutrinos which would produce events with $N_{hit} > 50$.

The detection volume V_{eff} for neutrino produced events with $N_{hit} > 50$ which fulfill all trigger conditions was calculated as a function of neutrino energy and zenith angle θ. V_{eff} rises from $2\cdot10^5$ m^3 for 10 TeV up to $6\cdot10^6$ m^3 for 10^4 TeV and significantly exceeds the geometrical volume $V_g \approx 10^5$ m^3 of *NT-200*.

Given an E^{-2} behaviour of the neutrino spectrum and a flavor ratio $(\nu_e+\tilde{\nu_e}) : (\nu_\mu+\tilde{\nu_\mu}) = 1:2$, the combined 90% C.L. upper limit obtained with the Baikal neutrino telescopes *NT-200* (234 days) and *NT-96* [4] (70 days) is:

$$\Phi_{(\nu_e+\tilde{\nu_e})}E^2 < (1.3\div1.9)\cdot10^{-6}\mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{sr}^{-1}\mathrm{GeV} \quad (1)$$

where the upper value allows for the strongest light scattering observed over many seasons.

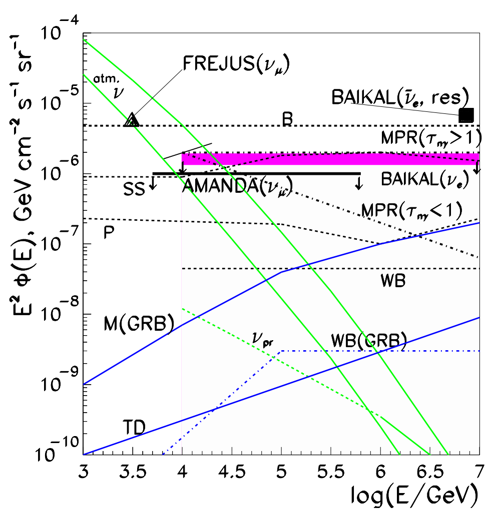

Figure 2. Experimental upper limits on the neutrino fluxes as well as flux predictions in different models of neutrino sources (see text).

Fig.2 shows the upper limits on the isotropic diffuse neutrino flux obtained by BAIKAL (this work), AMANDA [5] and FREJUS [6] (triangle) as well as the atmospheric conventional neutrino fluxes [7] from horizontal and vertical directions (upper and lower curves, respectively) and atmospheric prompt neutrino flux [8] (curve labeled ν_{pr}). Also shown is the model independent upper limit on the diffuse high energy neutrino flux obtained by Berezinsky [9] (curve labeled 'B'), and predictions for diffuse neutrino fluxes from Stecker and Salamon [10] ('SS') and Protheroe [11] ('P'). Curves labeled 'MPR' and 'WB' show the upper bounds obtained by Mannheim et al. [12] as well as the upper bound obtained by Waxman and Bahcall [13], respectively. Curves labeled 'M(GRB)' and 'WB(GRB)' present the upper bounds for diffuse neutrino flux from GRBs derived by Mannheim [14] and Waxman and Bahcall [15]. The curve labeled 'TD' shows the prediction for neutrino flux from topological defects due to specific top-down scenario BHS1 [16].

Our combined 90% C.L. limit at the W - resonance energy is:

$$\frac{d\Phi_{\bar{\nu}}}{dE_{\bar{\nu}}} \leq (1.4 \div 1.9) \times 10^{-19} \mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{sr}^{-1}\mathrm{GeV}^{-1} \quad (2)$$

and is given by the rectangle in Fig.2.

3. CONCLUSION

The neutrino telescope *NT-200* is taking data since April 1998. It performs investigations of atmospheric muons and neutrinos, and searches for WIMPs, magnetic monopoles and extraterrestrial high energy neutrinos.

In the next 2 years we plan to increase the sensitivity to diffuse fluxes by a factor of four. With a moderate upgrade of only 22 optical modules at three additionals strings we would reach a sensitivity of $\Phi_\nu E^2 \leq 3 \cdot 10^{-7} \mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{sr}^{-1}\mathrm{GeV}$. This upgrade towards a 10 Mton detector *NT-200+* is sketched in fig.3.

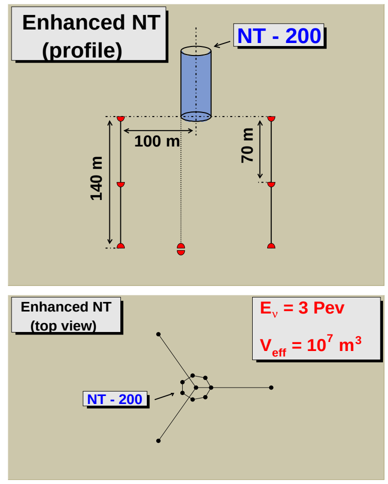

Figure 3. Sketch of *NT-200+*.

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